California's Solar Resources

2005 Integrated Energy Policy Report Workshop

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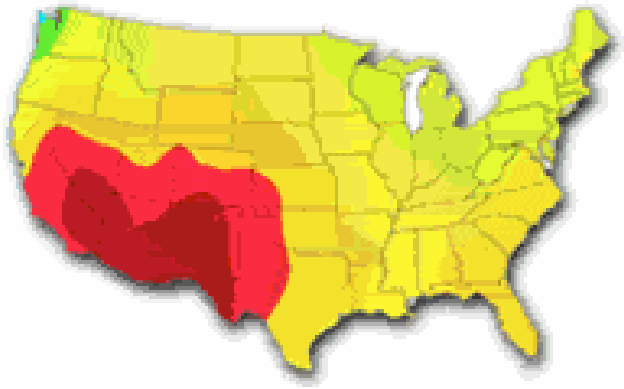
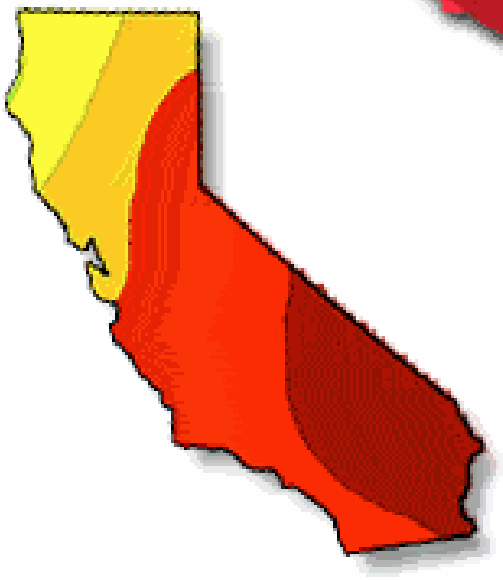
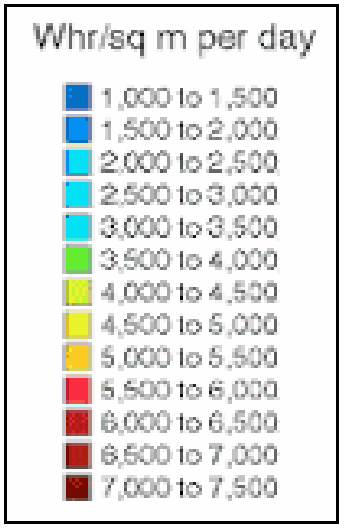
California Has Tremendous Solar Resources

Easy to “feel” but difficult to quantify solar potential







Source: NREL

Goals

- *Estimate solar resources in CA*
  - *Gross potential*
  - *Technical potential*
- *Two types of applications*
  - *PV*
  - *CSP*

General Approach

- *Insolation Values for CA*
  - *From NREL's Climatological Radiation Model*
    - ✓ *10 x10 km grids*
- *GIS Application*
  - *Gross potential and distributions*
- *GIS Filtering*
  - *Technical potential and distributions*

Example: Estimating PV Potential

COUNT	PV1G	AREA (sq. meter)	PERIMETER (km)	X_COORD	Y_COORD	JANUARY (kwhr/m2-day)	FEBRUARY (kwhr/m2-day)	MARCH (kwhr/m2-day)
163	2	204470541.05909	76516.54998	-124.270	42.046	2.920	3.480	4.170
2638	2	204470541.05909	76516.54998	-124.270	42.046	2.920	3.480	4.170
3999	2	204470541.05909	76516.54998	-124.270	42.046	2.920	3.480	4.170
266	2	204470541.05909	76516.54998	-124.270	42.046	2.920	3.480	4.170
543	2	204470541.05909	76516.54998	-124.270	42.046	2.920	3.480	4.170
144	2	204470541.05909	76516.54998	-124.270	42.046	2.920	3.480	4.170
12	2	204470541.05909	76516.54998	-124.270	42.046	2.920	3.480	4.170
4084	2	204470541.05909	76516.54998	-124.270	42.046	2.920	3.480	4.170
1984	2	204470541.05909	76516.54998	-124.270	42.046	2.920	3.480	4.170
117	2	204470541.05909	76516.54998	-124.270	42.046	2.920	3.480	4.170
39	2	204470541.05909	76516.54998	-124.270	42.046	2.920	3.480	4.170
590	2	204470541.05909	76516.54998	-124.270	42.046	2.920	3.480	4.170
126	2	204470541.05909	76516.54998	-124.270	42.046	2.920	3.480	4.170

<u>Steps:</u>

1) NREL insolation values obtained

2) Aggregated over grid areas by county

3) Gross potential & GIS visualization

4) Filtering

5) Technical potential & GIS visualization

PV Technical Potential

Filters:

- excludes lands where PV is impractical (bodies of water, forests, ag lands, sensitive habitats, etc.)
- excludes regions with north slopes greater than 5%
- assumes 10% system efficiency

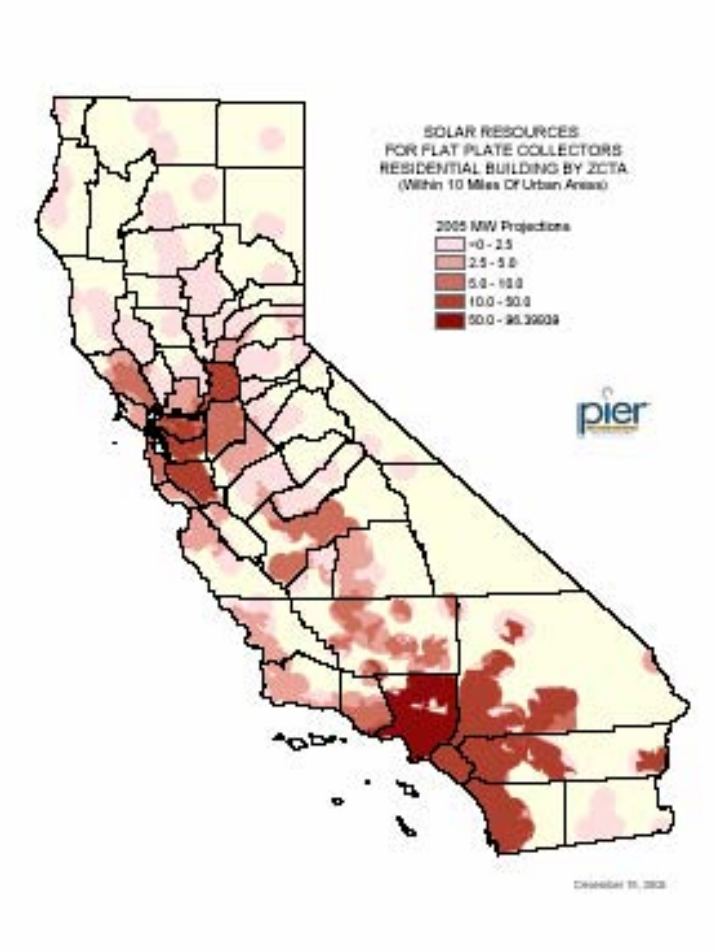
Represents potential for all types of PV applications

County Wide PV Technical Potential

County	MWh/day	MW	County	MWh/day	MW
ALAMEDA	558,952	103,745	ORANGE	811,245	149,772
ALPINE	268,655	48,905	PLACER	439,758	80,747
AMADOR	214,149	38,754	PLUMAS	397,814	71,626
BUTTE	439,566	80,810	RIVERSIDE	7,811,894	1,253,372
CALAVERAS	378,308	67,423	SACRAMENTO	814,573	147,775
COLUSA	317,045	58,227	SAN BENITO	822,419	150,298
CONTRA COSTA	498,774	91,151	SAN BERNARDINO	25,338,276	3,681,405
DEL NORTE	91,916	26,329	SAN DIEGO	3,561,569	605,526
EL DORADO	373,269	67,806	SAN FRANCISCO	38,977	7,410
FRESNO	1,821,168	317,682	SAN JOAQUIN	513,946	91,113
GLENN	547,123	98,508	SAN LUIS OBISPO	2,458,572	438,283
HUMBOLDT	397,805	68,340	SAN MATEO	251,470	47,153
IMPERIAL	4,698,212	745,887	SANTA BARBARA	1,699,109	287,137
INYO	10,047,177	1,599,946	SANTA CLARA	861,570	158,437
KERN	6,308,316	1,043,071	SANTA CRUZ	157,093	29,776
KINGS	502,002	86,687	SHASTA	895,729	164,584
LAKE	529,442	98,033	SIERRA	193,077	34,794
LASSEN	2,754,941	492,190	SISKIYOU	1,345,782	261,615
LOS ANGELES	3,912,346	662,486	SOLANO	453,180	83,335
MADERA	799,540	140,005	SONOMA	576,430	106,840
MARIN	249,559	45,458	STANISLAUS	795,435	140,865
MARIPOSA	549,329	96,867	SUTTER	98,023	18,717
MENDOCINO	665,493	124,389	TEHAMA	1,316,667	239,196
MERCED	1,034,145	183,450	TRINITY	331,254	59,027
MODOC	2,237,536	423,321	TULARE	1,251,596	217,308
MONO	2,036,827	349,025	TUOLUMNE	668,873	117,463
MONTEREY	1,875,717	339,488	VENTURA	1,136,758	199,073
NAPA	338,271	60,163	YOLO	376,907	67,518
NEVADA	199,567	35,236	YUBA	202,601	37,602
			State Totals:	100,139,176	16,822,184

Extremely large potential that significantly exceeds worldwide manufacturing capacities

Residential Rooftop Potential



Includes new and retrofit potential (15 million homes)

Assumes typical PV rooftop system of 2.5 kw

Total potential ~ 38,000 MW

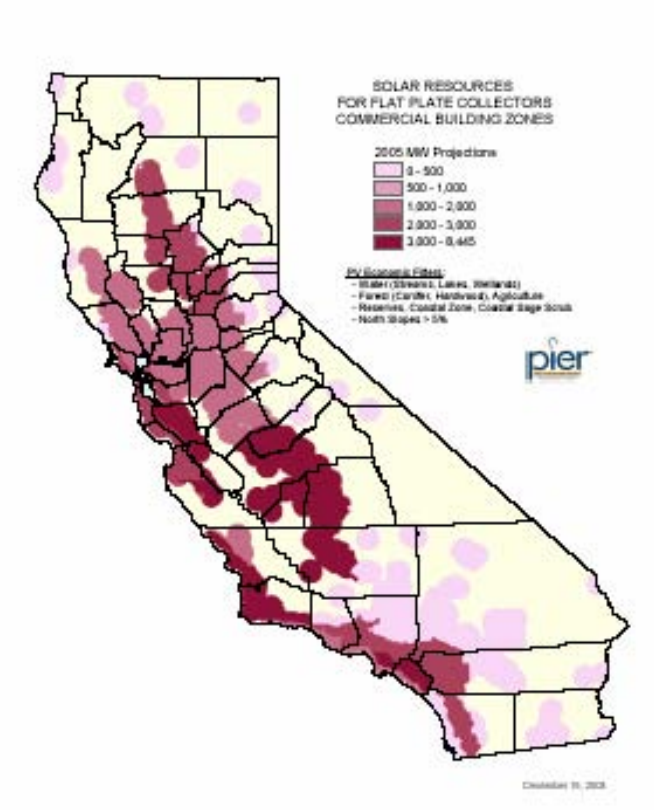
Distributions largely follow housing: Bay Area and So. CA

New Residential PV Rooftop

County	PV Capacity (kw)	County	PV Capacity (kw)
ALAMEDA	8,088	PLACER	2,558
ALPINE	0	PLUMAS	8
AMADOR	50	RIVERSIDE	41,868
BUTTE	717	SACRAMENTO	11,877
CALAVERAS	266	SAN BENITO	80
COLUSA	35	SAN BERNARDINO	33,100
CONTRA COSTA	3,445	SAN DIEGO	37,796
DEL NORTE	10	SAN FRANCISCO	-338
EL DORADO	1,279	SAN JOAQUIN	3,800
FRESNO	4,944	SAN LUIS OBISPO	1,396
GLENN	53	SAN MATEO	1,678
HUMBOLDT	143	SANTA BARBARA	1,396
IMPERIAL	577	SANTA CLARA	12,145
INYO	1	SANTA CRUZ	923
KERN	6,042	SHASTA	471
KINGS	220	SIERRA	2
LAKE	321	SISKIYOU	37
LASSEN	20	SOLANO	1,048
LOS ANGELES	217,847	SONOMA	2,931
MADERA	359	STANISLAUS	2,518
MARIN	352	SUTTER	189
MARIPOSA	22	TEHAMA	112
MENDOCINO	160	TRINITY	0
MERCED	770	TULARE	2,108
MODOC	1	TUOLUMNE	137
MONO	10	VENTURA	3,073
MONTEREY	1,588	YOLO	335
NAPA	157	YUBA	109
NEVADA	186	Total (kW):	436,246
ORANGE	27,229	Total (MW)	436

Total potential (2005): ~ 400 MW

Commercial Rooftop Potential



Includes new and retrofit potential and uses CEC estimates & forecasts for commercial square footage

Assumes:

- 10% system efficiency
- 3 floors per building
- 50% of roof area available (shading)

Excludes:

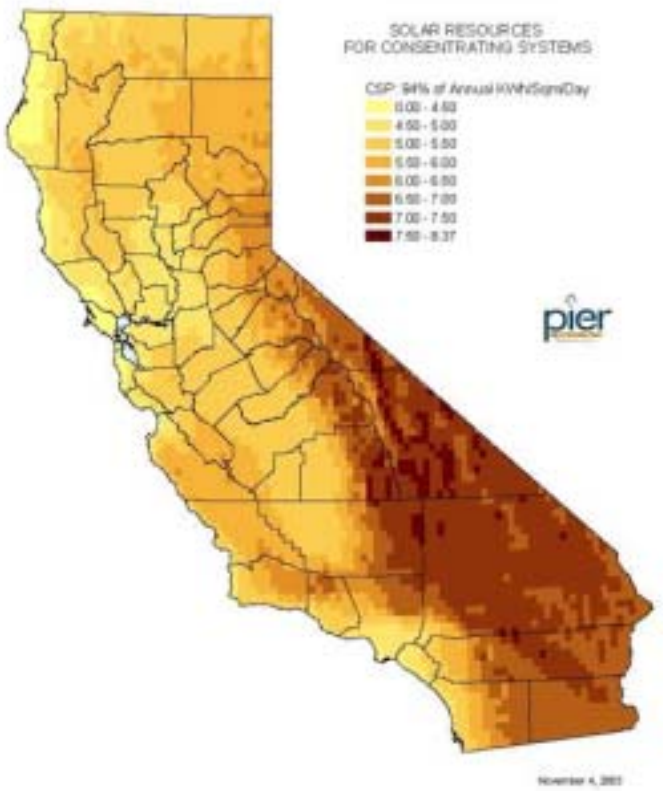
- Large bodies of water, forested areas, north sloping roofs, etc.

Total potential ~ 38,000 MW

Commercial Building PV Potential

County	PV Capacity (kw)	County	PV Capacity (kw)
ALAMEDA	377,922	PLACER	252,236
ALPINE	7,268	PLUMAS	23,486
AMADOR	65,339	RIVERSIDE	1,337,365
BUTTE	553,730	SACRAMENTO	162,052
CALAVERAS	106,604	SAN BENITO	838,844
COLUSA	225,158	SAN BERNARDINO	604,112
CONTRA COSTA	170,641	SAN DIEGO	1,378,654
DEL NORTE	64,031	SAN FRANCISCO	44,470
EL DORADO	138,096	SAN JOAQUIN	231,338
FRESNO	1,013,540	SAN LUIS OBISPO	3,045,804
GLENN	265,043	SAN MATEO	406,231
HUMBOLDT	276,242	SANTA BARBARA	3,258,365
IMPERIAL	28	SANTA CLARA	1,846,128
INYO	22,998	SANTA CRUZ	419,817
KERN	927,903	SHASTA	375,095
KINGS	371,712	SIERRA	7,637
LAKE	248,295	SISKIYOU	64,255
LASSEN	32,482	SOLANO	161,776
LOS ANGELES	4,478,579	SONOMA	374,731
MADERA	455,942	STANISLAUS	198,513
MARIN	275,934	SUTTER	225,417
MARIPOSA	19,355	TEHAMA	460,026
MENDOCINO	358,864	TRINITY	1,094
MERCED	255,528	TULARE	767,157
MODOC	24,050	TUOLUMNE	81,648
MONO	20,387	VENTURA	1,284,495
MONTEREY	1,843,157	YOLO	106,445
NAPA	168,419	YUBA	208,876
NEVADA	204,787	Total:	37,576,676
ORANGE	6,438,578	Total MW	37,577

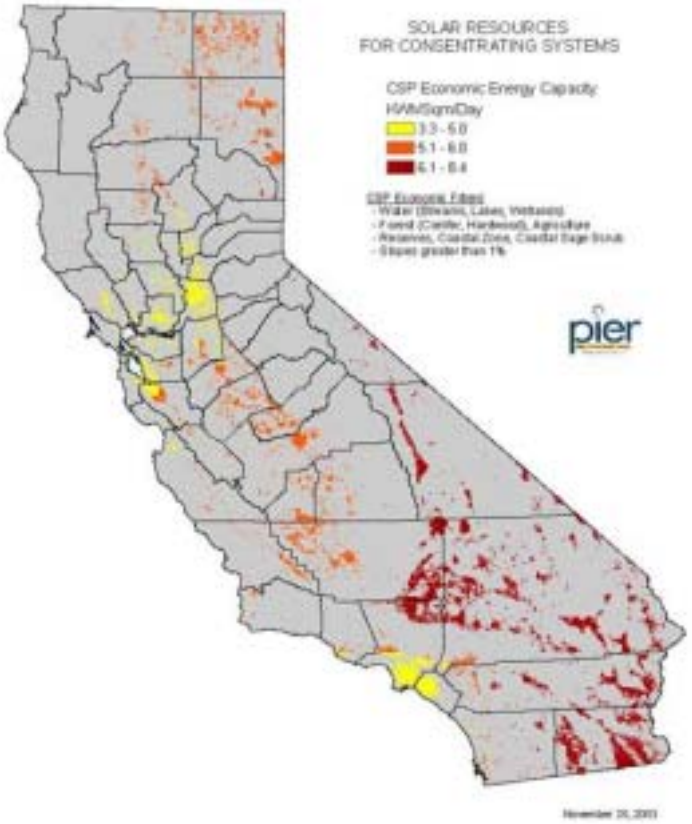
Gross CSP Potential



Dependent on direct beam radiation

- Resource largely in southeast CA

CSP Technical Potential



Filtered:

- Excludes bodies of water, pristine areas, roads, etc.
- Assumes 15% system efficiency
- Packing factor of 2
- No greater than 1% slope
- Only at locations where avg. annual direct beam radiation is greater than 6 kwhr/day-m^2

County Wide CSP Technical Potential

County	Acres	Total kW	Total MW	Total MWH
San Bernardino	1,256,034	381,158,658	381,159	988,016,559
Imperial	725,634	220,243,536	220,244	547,972,905
Riverside	419,267	127,160,811	127,161	318,998,213
Kern	418,639	127,029,235	127,029	330,488,517
Inyo	334,694	101,581,377	101,581	270,324,760
Los Angeles	244,572	74,232,750	74,233	189,442,262
Mono	39,716	12,054,750	12,055	30,997,196
San Diego	25,325	7,686,750	7,687	18,628,313
Lassen	24,302	7,376,250	7,376	16,377,260
Plumas	5,281	1,602,750	1,603	3,520,275
El Dorado	1,473	447,000	447	996,984
Santa Barbara	956	290,250	290	652,998
Sierra	638	193,500	194	437,858
Nevada	489	148,500	149	341,476
Placer	324	98,250	98	225,926
Modoc	185	56,250	56	123,393
Total	**3,497,530**	**1,061,360,617**	**1,061,361**	**2,717,544,893**

Conclusions

- ***California has tremendous, largely untapped solar resources***
  - ***PV Technical Potential***
  - ***Generally good throughout the state***
    - ✓ ***Residential Rooftop PV (new & retrofit): 38,000 MW***
    - ✓ ***Commercial Rooftop PV: > 37,000 MW***
    - ✓ ***New Residential PV: > 400 MW annually***
  - ***CSP Technical Potential***
  - ***Located primarily in southeast portion of the state***
    - ✓ ***~ 1 Million MW of potential capacity***